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BATTALION COMMAND AND CONTROL

JULY 1977

PREPARED BY

SYSTEMS FORCE MIX DIRECTORATE

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This paper defines the current maneuver Battalion Command and Control System in combat and the information flow within the system. Several levels of hierarchical (top down) process flow of battalion operation are presented in flowchart format. These diagrams encompass the combat functions of the battalion together with the command and control functions. Future efforts are required to further detail the logic of battalion operations and to determine the parameters considered by the decision maker under combat conditions. Application of these results to combat simulations would improve the analysis of battalion C&C Systems.

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25 July 1977

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PREFACE

There is a lack of analytical information concerning the battalion echelon command and control process; no methodology is known to exist for the quantitative analysis of the process. To develop such a methodology, the battalion command and control process must first be analyzed and defined. This paper defines the current maneuver battalion command and control system and the information flow within this system. Several levels of hierarchical process flow of battalion operation are presented in flowchart format. These diagrams encompass the combat functions of the battalion together with the command and control functions. Prior to computer simulation, future efforts will be required to further detail the logic of battalion operations and to determine the parameters considered by the decision maker under combat conditions. Application of these results to combat simulations would allow quantitative analysis of the battalion command and control system(s) and permit trade-offs between competing materiel support systems.

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CHAPTER 1
INTRODUCTION

1-1. BACKGROUND. Published research concerning command and control systems either has been oriented toward organizations at division echelon and above or has tended to concentrate on individual hardware and software systems such as the Tactical Operations System. None is known to have analyzed the total system, including the individual decision maker, as it is employed in combat by a maneuver battalion. Principal analytical measures used previously were individual system performance and efficiency, (e.g., message failures, throughput, and targets acquired) rather than measurement of the change in combat effectiveness of the unit due to changes in the total command and control system. The result is a lack of systematic analysis of command and control below division. This has limited analyses of potential command and control system trade-offs and of trade-offs between dissimilar systems to qualitative methods. A simulation of maneuver battalion combat containing all organic systems would provide the Army analytical community with a tool to provide a better understanding of system trade-offs. Such a simulation could also provide, or verify, modifying factors for higher echelon combat simulations. This paper represents an initial step in the analysis of command and control in combat at echelons below division.

1-2. PURPOSE. The purpose of this paper is to document what has been learned during this study and to provide reference material for any subsequent analysis of battalion command and control in combat.

1-3. OBJECTIVES. This study develops and provides an analytical definition of the current maneuver Battalion Command and Control system to include:

a. Information flow within the system.

b. Logic of current system operation.

1-4. METHODOLOGY. a. Work on this project was initiated by a search of existing documentation on command and control processes. A literature search included the Army Study Documentation and Information Retrieval System and the Defense Documentation Center computerized data bank. The literature reviewed is listed in Appendix B. In addition, contacts within the Army command and control research and development community were established to collect current documentation relative to command and control and to exchange views and concepts on command and control in a maneuver battalion. These contacts included representatives of:

(1) TRADOC Systems Analysis Activity

(2) Combined Arms Combat Development Activity

(3) Command and General Staff College

(4) Army Research Institute

(5) Combined Arms Tactical Training Simulator

(6) Armor School

(7) Infantry School

b. The basic decision-making process represented in FM 101-5 was charted and combined with the definition of Command and Control found in AR 310-25 to develop a system description for the battalion level; the system description developed is found in chapter 2. Subsequently, the logic of the command and control processes was synthesized and is described in Chapters 3 and 4.

c. Concurrent with the development of system description and logic, research was conducted in the area of decision theory. In addition, the suitability of current models that might be adaptable to analyses of the Battalion Command and Control system was investigated. This research is summarized in Appendixes C and D.

1-5. COMMAND AND CONTROL DEFINITION. A command and control system is defined as "the facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions."* Analysis of this definition permits identification of its components: Elements, Decision-maker, Functions and Mission. The lements (facilities, equipment, personnel, communications, and procedures) are the tools required by the decision-maker (commander) to perform the management functions (planning, directing, and controlling) to accomplish his mission. This compartmental definition is illustrated in Figure 1-1. FM 71-2 states, "Command is a very personal thing,"** and, as a result, the individual Battalion Command and Control system will vary between commanders within the constraints of the formal definition.

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*AR 310-25, 1 June 1972, p 127

**FM 71-2, 23 July 1976 (draft), p 3-14, 3-15

ELEMENTS	DECISION MAKER	FUNCTIONS	MISSION
FACILITIES			
EQUIPMENT		PLANNING	
COMMUNICATIONS	COMMANDER	DIRECTING	OPERATIONS
PROCEDURES		CONTROLLING	
PERSONNEL			

Figure 1-1. Command and Control System Definition

CHAPTER 2
COMMAND AND CONTROL INFORMATION FLOW AND DECISION PROCESS

2-1. INTRODUCTION. The Battalion Command and Control system defined in the previous chapter can be considered to encompass other types of systems for analytical purposes. Since there is a flow of information within the command and control system, without which the system presumably would not work, at least portions of the command and control system can be likened to an information processing system. The decision making system (commander) does not process information per se but rather uses information to formulate a plan which ultimately results in the issuance of orders--the directing function of command and control. The separation of command and staff actions into these two types of systems is shown in Figure 2-1. It should be noted that the use of the word "information" in this context is a broad one including both intelligence and combat information as well as directives from higher headquarters. A block diagram, Figure 2-2, shows the information flow within the command and control system. It is the total of all the pieces of information which enters into the general function which has been termed "Collection" in this figure. (This summation of information is a variable based on the quality of the information collection system). Through the use of the personnel and equipment within the allocated facilities this mass of information is analyzed, synthesized, and otherwise processed. The commander at each decision point may then call upon the system to provide pertinent data for each decision as it arises. Of course, he is not prevented from further diagnosing or amending the data he receives. Factors such as experience contribute to such amendments prior to the decision and subsequent issuance of the order or guidance.

2-2. INFORMATION PROCESSING. a. Within the command and control system, information takes several forms. At its arrival into the system, it is a combination of raw data and synthesized data. This information is converted, where possible, to ncrease the proportion of synthesized data (data which have been analyzed and combined with previous data). The combination is stored for retrieval by the commander or his support staff. As new combat data are received, they are added to the existing store of knowlege, in a synthesized form if possible. As the commander retrieves information, he can, at his option, further change or add to it. Upon reaching his decision, the factors considered in that decision are melded into a new form as well as being retained in their previous form. The new form is his order.

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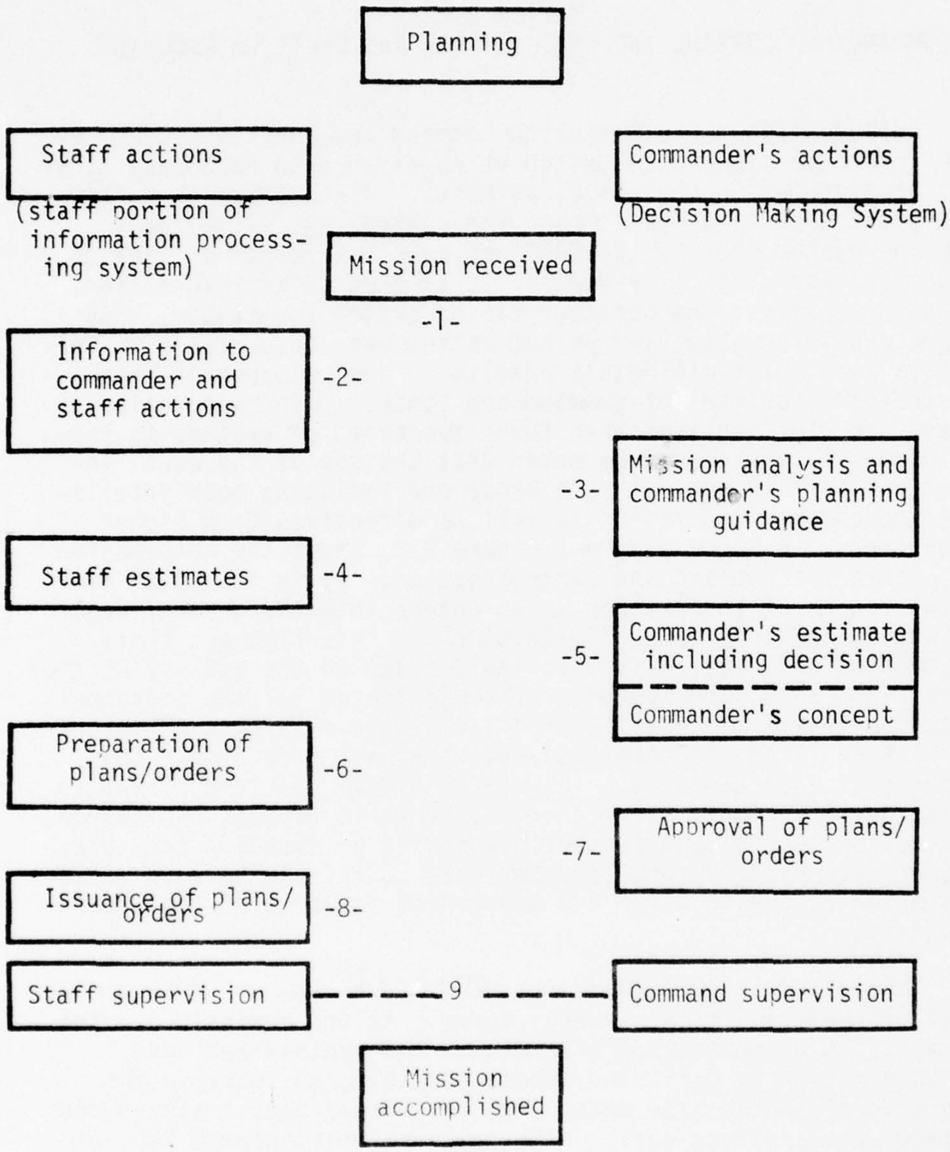

Figure 2-1, Command and Staff Actions[a]

[a]Field Manual 101-5, p 5-14

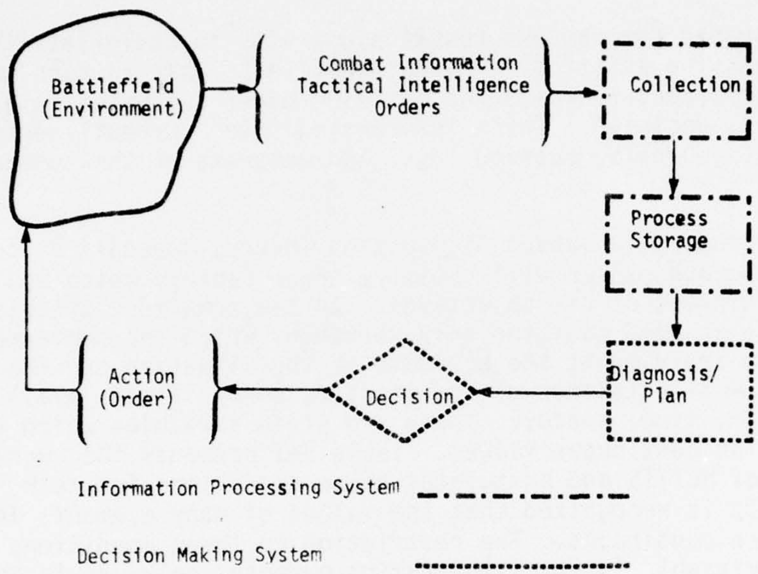

Figure 2-2. Command and Control Information Flow

b. The environment in Figure 2-2 is the commander's area of influence and interest. All forces must be accounted for in this environment: his superiors and subordinates, the enemy, those weapons and equipment outside his geographical area which can cause effects within it, and those forces which will shortly come within the geographical area. Thus, the commander's environment is the source of all information which he considers. In fact, one of the functions of combat information processing is that of filtering extraneous information from outside his environment.

2-3. DECISION MAKING. The intent of the combat orders issued by the commander is to alter the environment in some manner, e.g., change unit locations, cause enemy attrition, reinforce units. This order, in combination with other orders, can be assessed as to its effect on the environment. This is the commander's basis for determining whether the mission has been accomplished. In modeling and studies this effect is the measure of combat/force effectiveness. In combat the effect on environment is assessed by the sensing system (e.g., radar, observations). Again, the broad definition of sensing is used, hence the inclusion of human eyes and other human senses with electronic systems. Each time infor-

mation is sensed the process function operates to assimilate the new data into the existing "information file." This in turn may reset those parameters which the decision maker evaluates in arriving at his decision. This "information file" currently exists in the maps, journals, message logs, and memories of the commander and staff.

a. Game theory (a subset of Decision Theory, Appendix B) postulates that each player will optimize those factors which would lead to attainment of his objectives. In the remainder of this paper, it is assumed that the only variables which the commander considers in arriving at the estimate of the situation are the elements of METTTS (states of the mission, enemy, troops available, terrain, time, space). These are state variables which generally take on continuous values. Table 2-1 presents the current definition of METTTS and postulates three conditions for each variable. It is recognized that the values of many elements in real life are continuous. The restriction to three conditions for each state variable is for illustrative purposes only, as is the restriction to six state variables. As previously mentioned, further research in military decision making is required to determine the list of variables to be used.

Table 2-1. Command Decisions

	Variables	State
M	Mission	Attack, Defend, Retrograde
E	Enemy	Heavy, Moderate, Light
T	Troops Available	Heavy, Moderate, Light
T	Terrain/Weather	Good, Indifferent, Bad
T	Time Available	Long, Moderate, Short
S	Space (Maneuver)	Unrestricted, Moderately Restricted, Restricted

b. The assumptions suggested by METTTS are that the commander knows certain information and estimates certain information, thus leading to actual and inferred, or perceived, states respectively. One additional state can be considered: the desired state. The hypothesis is that if the commander's environment is the actual

state, his imperfect knowledge degrades this actual state to the inferred state and his mission is planned to lead him toward the desired state. Any time the inferred and desired states are not the same he will make a combat decision to act. During combat the inferred and desired states will seldom, if ever, be congruent. This is due to the changing of the desired state by the commander's reassessment or by preparation for future courses of action. The inferred state can be altered also by new information concerning one or more of the decision variables. The commander will continue to make combat decisions based on the METTTS variables until the states are identical due to cessation of combat.

c. Consider the situation where the commander is given the mission to attack. The mission variable of METTTS is a "given" and hence actual and inferred states are equal, but could be changed at a later time by authority of higher echelon commanders or by the battalion commander's analysis of potential future missions. An example of actual, inferred, and desired states is given in Table 2-2.

Table 2-2. Decision Variable Examples

Variable	Mission	Enemy	Troops	Terrain	Time	Space
Desired state	Attack	Light	Heavy	Good	Long	Unrestricted
Inferred state	Attack	Light	Moderate	Bad	Long	Unrestricted
Actual state	Attack	Moderate	Moderate	Bad	Moderate	Unrestricted

(1) In this example it can be seen that the commander is facing a moderate strength enemy force with his own unit having moderate strength in bad terrain with a moderate amount of time available to react. Decisions he makes will be based upon the inferred state of the environment which is not identical to the actual state due to imprecise, imperfect, or otherwise faulty information. Therefore, given superior forces, the commander may first attempt to maneuver to better terrain. Had his information been perfect (or at least better), he would have known that the enemy force approximated his strength and was concentrated closer to his units, giving a shorter time element than he estimated. The outcome of the attempted maneuver toward better terrain is based on the reactions of this higher strength enemy force. The command and control system provided him with erroneous informa-

tion, possibly causing him to execute the wrong decision which could result in a different outcome than desired.

(2) If the command and control system which provided the information in Table 2-2 were different due to an alternative configuration, the two "competitive" systems could be compared based on resultant combat measures of effectiveness, i.e., the combat outcomes of two identical battalions each employing a different command and control system. The quality of the information provided to the decision maker directly affects the decision made, thus translating the performance measures (speed, efficiency, and quantity) into combat outcomes.

(3) To further consider the previous example, the commander (in the inferred state) in general desires to maximize his forces and minimize the enemy forces in the best terrain with maximum time to react and space to maneuver. The situation may prevent such actions, however. An attack order contains many elements to be considered in the planning phase of the combat. It may not permit a change of terrain or an increase in forces. If it does not, the commander could decide to request such changes if they impact on the higher echelon's environment. If the request or orders prevent such actions, as is usually the case at battalion, the commander can never enter the desired state but will still try to optimize the remaining factors.

(4) It should be remembered that the commander is not considering one sequence of decisions but rather a series of overlapping decisions and actions. The result of this sequence is the outcome of the combat. Such a multiplicity of information flow, both to and from the commander, is a cause of queuing in the various subsystems, e.g., fire requests to artillery and calls through the communications system in excess of its capacity.

CHAPTER 3
COMMAND AND CONTROL LOGIC

3-1. SYSTEM LOGIC. From a logical viewpoint, the Battalion Command and Control system can be diagramed as a process flowchart (Figure 3-1). From this overview, it is seen that the overall process begins with receipt of combat orders from higher echelons which are then processed through the planning phase resulting in directions to the battalion elements for their portions of combat. In the planning phase alternative plans are determined which must be evaluated with the resultant selection of the "best" plan for the battalion. Other plans considered may become contingencies to be acted upon when the original plan must be replaced or altered. Upon receipt of subsequent orders to "act" the EXECUTE process, which controls all processes needed during combat, is started. Movement is "begun" at any velocity: positive, negative, or zero (i.e., depending on METTTS factors, movement could be in any direction at any allowable velocity, including zero). During movement, personnel do not turn off their senses so that the human sensing process called OBSERVE is always providing additional information. Decisions are required to obtain electronic surveillance by the SENSOR process, to provide FIRE SUPPORT and DIRECT FIRE on targets, and to change plans. Upon completion of the optional processes the EXECUTE process is continued. Once the sequence of decisions and actions is completed, the EXECUTE process is repeated and each decision is reevaluated by the commander. It is assumed that within each process are communications effects, the expenditure/resupply process, and damage assessment. Of these only some communications delays will be illustrated in this paper.

3-2. DETAILED LOGIC. Each of the processes and functions of the abbreviated logic diagram (Figure 3-1) has been flowcharted in greater detail. Future work must provide even greater detail if the command and control process is to be simulated by a computer model. The detailed logic is shown in Figures 3-2 through 3-7 with narrative explanations of each of these subroutines contained in the following paragraphs. It should be noted that certain details are not duplicated in each flowchart such as the decision to communicate and the question of ability to communicate. Analysis required for the decision is assumed to be included in the decision block. An additional level of analysis would include these details.

a. PLAN

(1) The logic for the process called PLAN is contained in Figure 3-2. Should no orders be received, the logical system allows the battalion to assess the "prepare to" portion of the

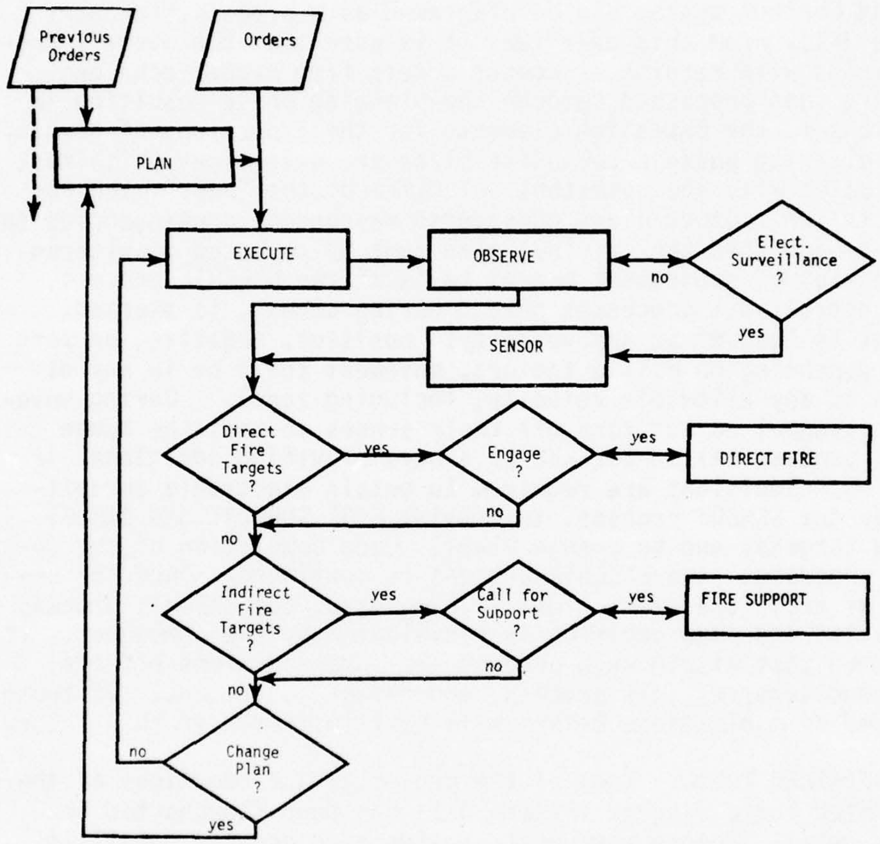

Figure 3-1. Process Flowchart, Top Level of Hierarchy

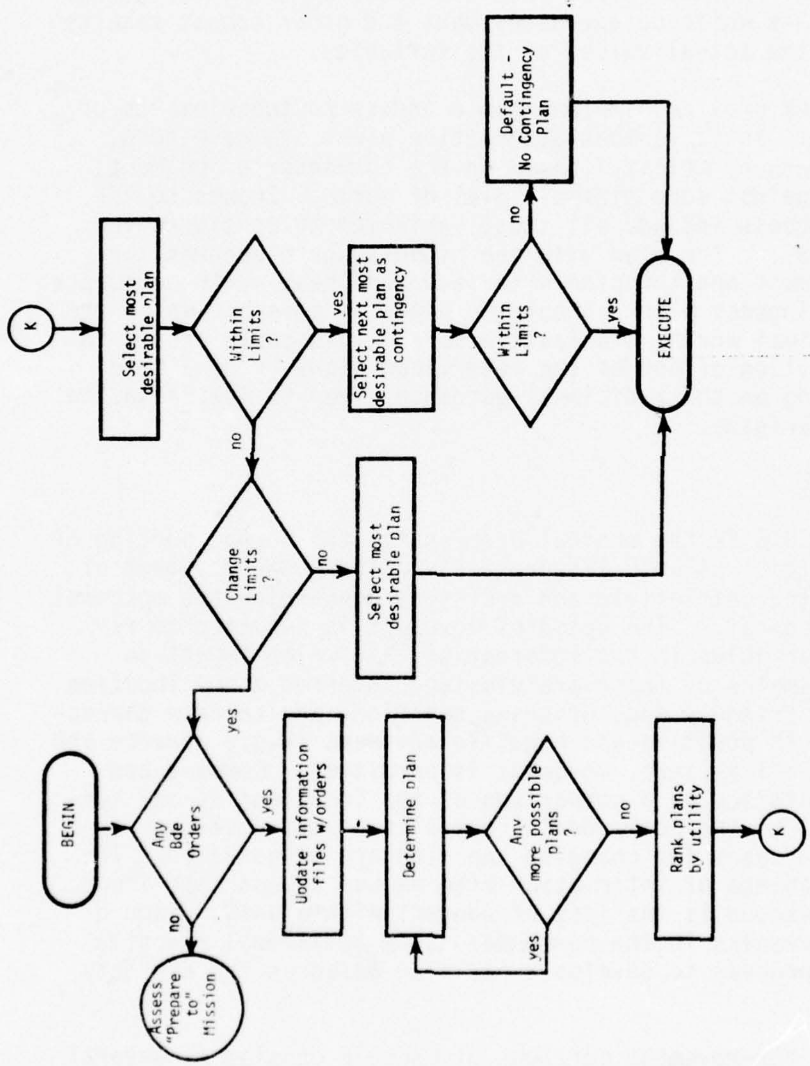

Figure 3-2. Flowchart of PLAN Process

previously received order. If orders are received, the variables in the commander's "file of information" (consisting of journals, maps and staff memories) are adjusted to any new values contained in the orders. This file must contain all variables which the decision maker utilizes to select the proper alternative. Those variables which are determined by intelligence and other variables which are estimated are in the commander's information file as the inferred state. Any decisions made are based on the inferred values of variables while damage assessment and other combat results are based on the actual values of the variables.

(2) PLAN provides implementable orders to the elements of the Battalion. In it various alternative plans are developed, ordered by worth or utility (based on the commander's judgment) and checked against some minimal level of worth. Inputs to the evaluation process include all those variables he considers for other decisions. The plan with the highest worth becomes the plan to implement and the plan with second highest worth becomes a possible contingency plan. Should no plans be possible which are above the minimal worth, a default occurs. This could result in the implementation of one of the determined plans or of a hold order depending on the additional guidance given to the Battalion commander by Brigade.

b. EXECUTE

(1) EXECUTE is the central process for the combat portion of the logic system. EXECUTE (Figure 3-3) includes the movement of the units on the battlefield and decisions concerning the optional processes of combat. The speed of movement is adjusted to reflect those variables in the information file which impact on movement. Examples of these are mission, inferred enemy location and strength, friendly mode of transportation, and terrain characteristics. Both positive and negative movement (e.g., advance and retreat), as well as zero, movement is permitted. Command and control is exercised by a comparison of the locations of the subordinate units to the commander's control measures developed in the plan. Two bases for changing the plan are illustrated. The first is the change of information file values beyond some input values. The second is the loss of contact with a unit. Each of these events results in the commander doing additional planning via the PLAN process to develop a new plan based on the new data available.

(2) The non-movement portions of EXECUTE consist of several decisions on the part of the commander. If electronic surveillance is desired, the SENSOR process enters the logical system; if the use of such devices is not desired, the process continues with only OBSERVE (human) inputs available to update the information file. When enemy units which exceed a threshhold of target worth

come within range of either indirect or direct fire systems, the FIRE SUPPORT or DIRECT FIRE processes are involved, depending on the information entering the commander's decisions. The communications effect on the process flow is a delay in transmission of information. Until updated information is transmitted and received, the combat proceeds without it.

c. OBSERVE. The flowchart for the OBSERVE process is shown in Figure 3-4. This process includes the human physical senses of sight, hearing, and smell used by personnel to provide information about the combat situation, specifically about the variables in the information file. Communication may not be permitted under certain conditions. If this is the case, only the local echelon information file is updated with new information; the battalion commander and staff would continue operating on older information until the communications limitations are changed. Shell Reports should be provided when fire has been or is being received. Data gathered from captured equipment, interrogated prisoners and discovered documents are also included in this process.

d. SENSOR. When electronic surveillance is desired, the SENSOR process (Figure 3-5) is invoked. The first question asked is whether any devices for such surveillance are organically available to the battalion. If not, the battalion obviously cannot deploy them. Given that devices are available, the deployment of the teams with the devices is made. The "team" is also given the characteristics of the device, their mission and information from the file which might affect the mission. The device is then switched on; if not operational in some number of attempts as determined by the commander, the surveillance mission is abandoned. If the device is operational the mission is then carried out with obtained information communicated (if possible) to the appropriate information files for comparison with other data and file update. A return is made to the EXECUTE process if additional missions are not desired.

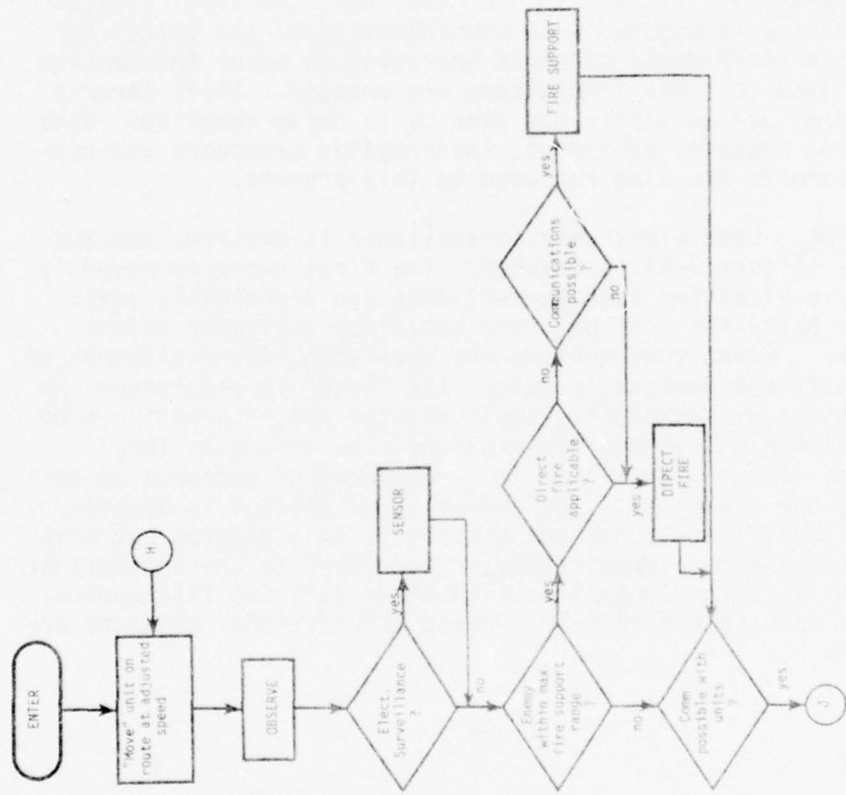

Figure 3-3, Part 1. Flowchart of EXECUTE Process

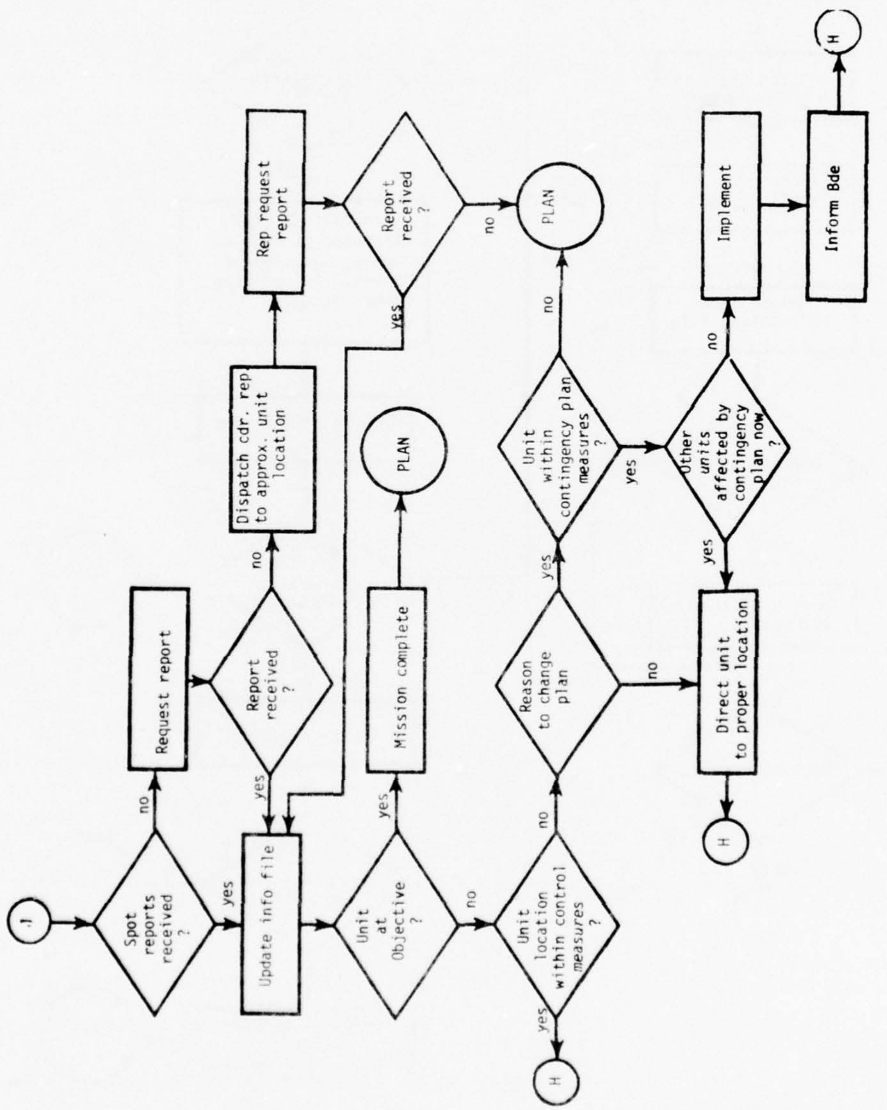

Figure 3-3, Part 2. Flowchart of EXECUTE Process

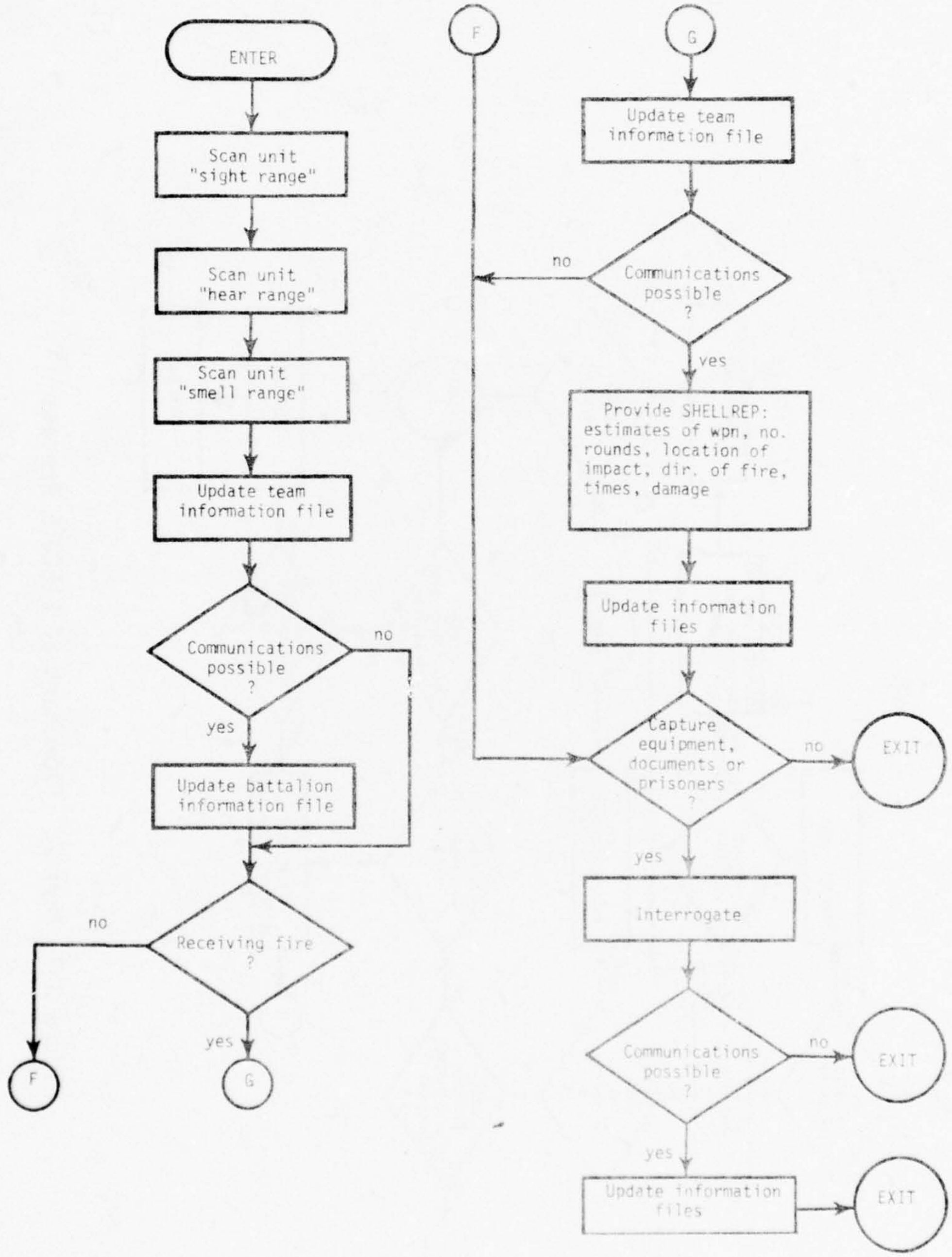

Figure 3-4. Flowchart of OBSERVOR Process

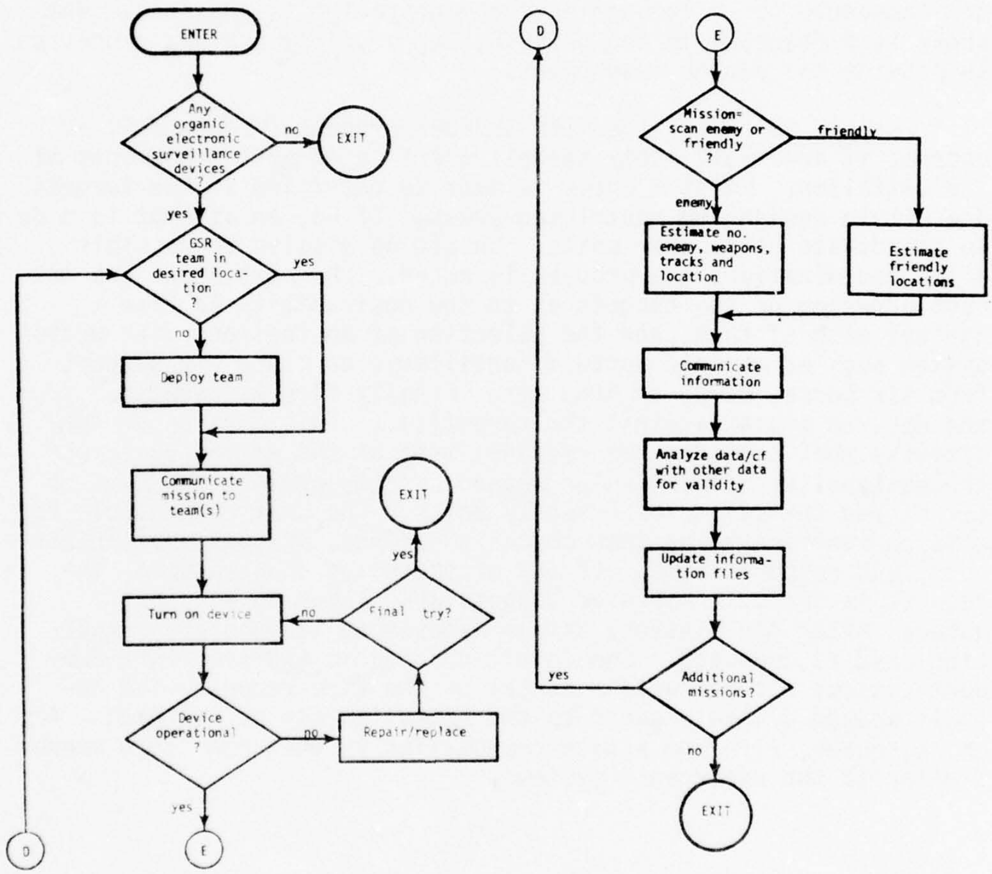

Figure 3-5. Flowchart of Process SENSOR

e. DIRECT FIRE. The DIRECT FIRE process is in Figure 3-6. This process is a straightforward sequence of computations to rank the targets by the threat, select the optimal target within range, select the ammunition for the effect desired, and fire all weapons within range of the target which are required to provide a desired probability of kill. Damage is assessed and ammunition used is calculated after each mission. Upon firing at the last target, the process is ended. Damage/logistics information is passed to the commander for file update if communication is possible. Not shown is a feadback to the OBSERVE, and possibly SENSOR, processes to provide the damage assessment.

f. FIRE SUPPORT. The FIRE SUPPORT process (Figure 3-7) is entered if desirable enemy targets are located by the elements of the battalion. First a check is made to determine if the targets are within designated restricted areas. If so, an attempt is made to coordinate with other units. Should no mission be possible after coordination, the process is ended. The next steps are the rank ordering of the targets as to the desirability to fire against each of them, and the selection of an indirect fire weapon system such as organic mortars, artillery, or close air support from Air Force, Navy, or Army air. Finally fire is requested from the desired system against the target(s). This portion of the activity must consider the response time of the weapon systems, the suitability of particular weapon systems against the type of target and the safety of friendly units. The unit responsible for mission implementation then checks the range, weapons appropriateness, and response time. If any of these are unacceptable, the request is denied. Approved targets are placed in a priority queue. After the mission, damage assessment is done and ammunition used is computed. Should all nonorganic indirect fire support systems respond with a denial of the fire request, the default weapon system organic to the battalion may be employed. A check, queue, fire and assess computation is then done in a manner similar to the nonorganic systems.

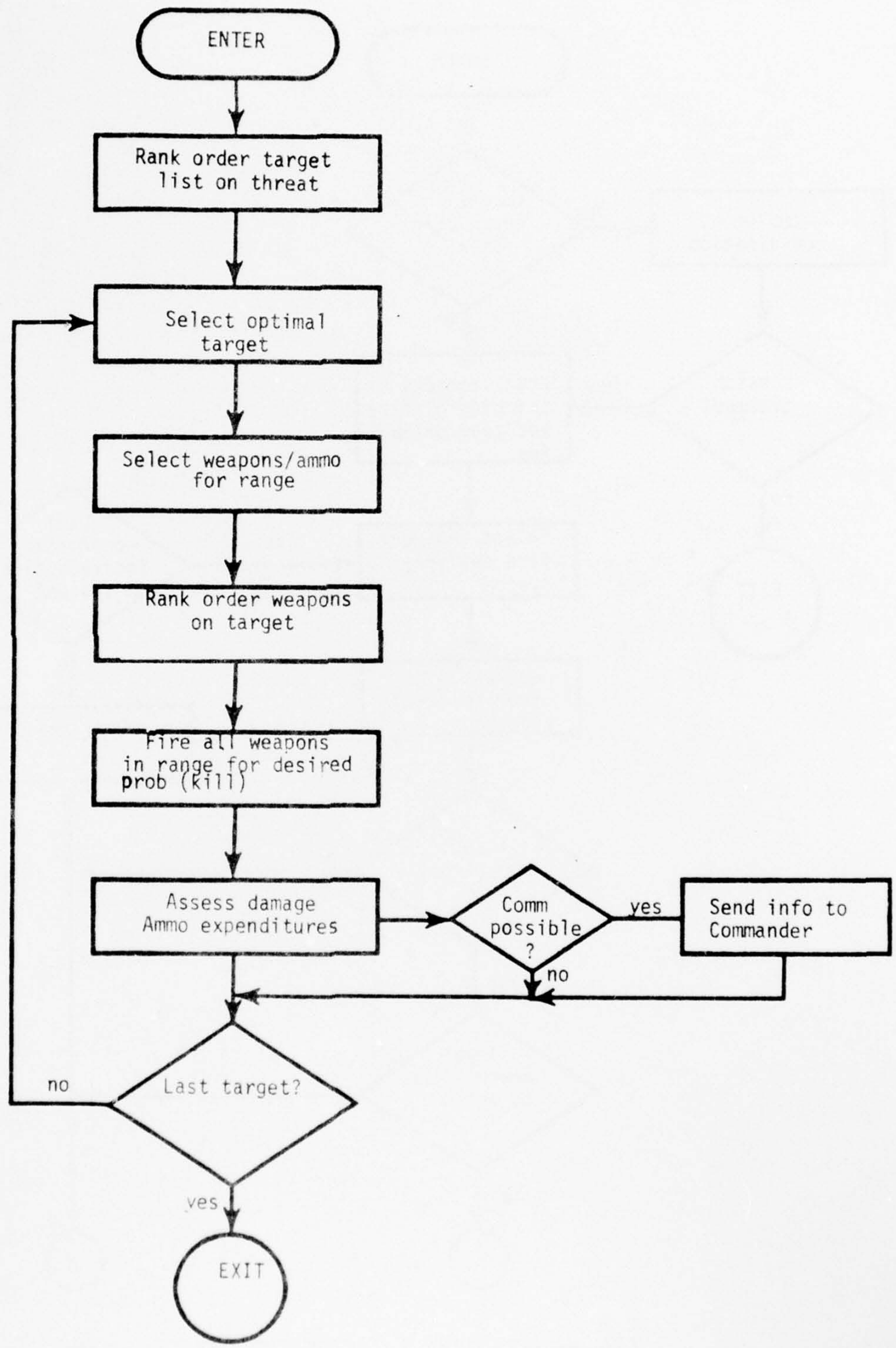

Figure 3-6. DIRECT FIRE Flowchart

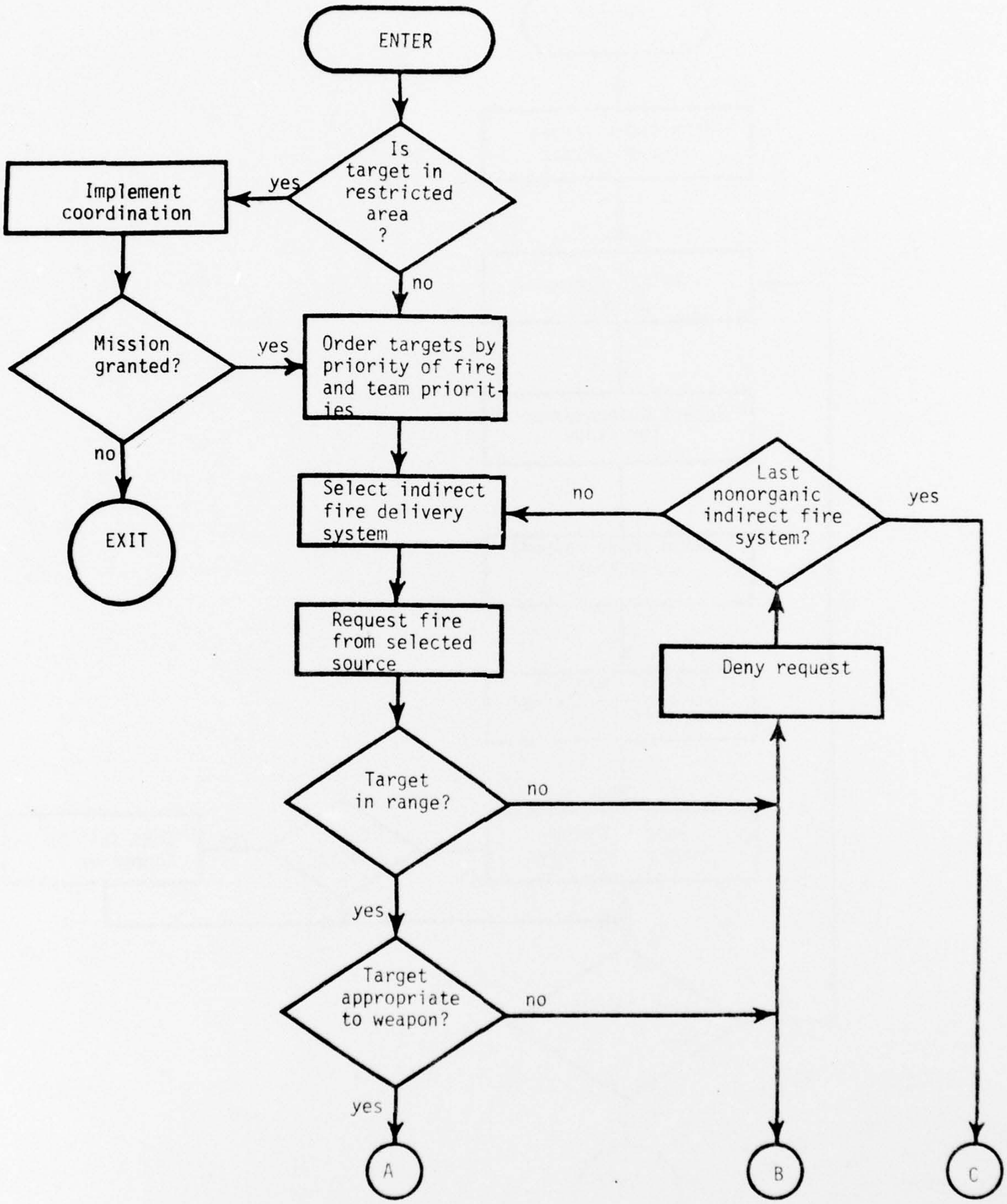

Figure 3-7, Part 1. FIRE SUPPORT Flowchart

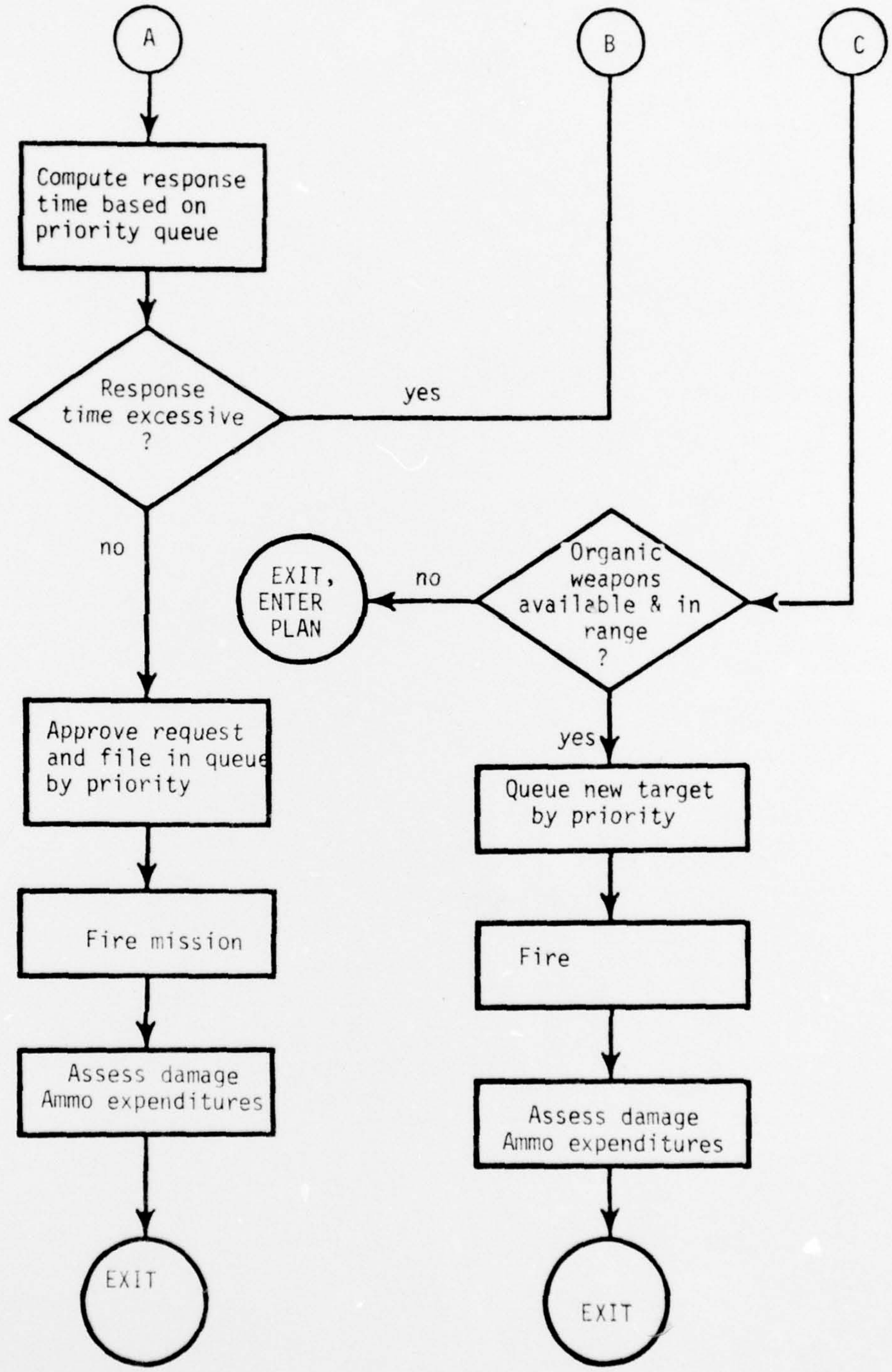

Figure 3-7, Part 2. FIRE SUPPORT Flowchart

CHAPTER 4
OBSERVATIONS AND FUTURE ACTIONS

4-1. OBSERVATIONS

a. Despite the availability of documentation on the subject of "Command and Control," there has been very little analysis of maneuver battalion command and control systems.

b. Types of information considered by the commander as a decision maker have not been fully identified or quantified. At best they are assumed.

c. It appears that simulation of the maneuver battalion command and control system process is possible using the logical processes identified in this paper.

4-2. FUTURE ACTIONS

a. The Human Research Need (Appendix E) has been submitted to the US Army Research Institute as a project for developing/obtaining the variables which input to the decision process of the battalion commander and his staff.

b. Once the variables are identified, they can be combined with the logic of the Battalion Command and Control system to provide a methodology for quantitative analysis of that system in combat.

c. The decision variables could also be used to improve the decision algorithms of current models.

APPENDIX A
STUDY CONTRIBUTORS

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APPENDIX B
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APPENDIX C
DECISION - THEORY

C-1. GENERAL. Decision theory has been studied for many years. An excellent bibliography is contained in Games and Decisions*. This Appendix is not intended to be an exhaustive brief of the subject but rather a short introduction to the subject with liberal reference to books in the field.

C-2. MILITARY DECISION MAKING a. Decision making is commonly partitioned based on whether the decision is made by an individual or a group. For the purposes of this paper all decisions are considered to be made by an individual rather than a group of individuals having potentially conflicting interests which must be resolved.

b. Each of these partitions is further divided by the conditions under which the decision is made: certainty, uncertainty or risk. To further "simplify" the military situation, consider the definitions of certainty, uncertainty, and risk.

(1) Certainty is knowing that each action will lead to a specific outcome: , e.g., if I walk on an operational land mine, I will be injured.

(2) Uncertainty is when each action can lead to a set of possible outcomes with unknown or possibly unmeaningful probabilities of occurrence.

(3) Risk falls between certainty and uncertainty in that each action leads to one of a set of possible outcomes each of which occurs with a known probability, e.g., a throw of a die, toss of a coin, the land mine whose operational state is unknown when walked upon, and Russian roulette.

c. The military decision maker seems to fall into the category of "individual decision making under uncertainty" for the most part. It is highly unlikely that an action based on perceived conditions in combat would result in specific predictable outcome or even one of a set of known outcomes. This categorization reduces the scope of the problem only in the sense of the number of categories that must be considered. Unfortunately, this category is not a simple one for analytical purposes.

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*Games and Decisions: Introduction and Critical Survey, Luce and Raiffa, Wiley and Sons, 1957, pp 485-499.

d. One may look to game theory as a means to analyze the military decision maker if all uncertainty in the battle can be blamed on the opponent, because in game theory, "uncertainty is due entirely to the unknown decisions of other players**." In the strictest sense, game theory is overly restrictive. It is generally modeled by assuming that each player knows the desires of the opponent and that they will optimize those factors or actions which appear to gain their objectives. Additional study of this application of game theory is recommended, for, despite its restrictions, it may prove to be a worthwhile tool for analysis of the decision process.

e. Specifically, the portion of game theory for further investigation is the "two-person non-zero-sum non-cooperative game." In this type of game, each player has a different set of desirable outcomes; the non-cooperative nature of the game means that there is no preplay communication, i.e., no agreements. These aspects of this subset of game theory seem to indicate that military, and other, conflicts may well fit within the restrictions. A further complicating factor is that the decisin process can be sequential with the results of one decision impacting on a subsequent decision. For analytical purposes of sequential decisions, Markovian processes should be considered.

f. As part of the decision process the commander develops a set of variables to alter or optimize. This then introduces Utility and Value theories***. Fuzzy Set Theory*** is also of interest due to imprecision involved in both the choice of action and the outcome of that action. It is these variables which need to be identified and quantified. The USACAA proposal for the Army Research Institute Human Needs Research Program is included as Appendix E.

**Ibid, p275.

***For additional research of these subjects the reader is referred to Fishborn, <u>Decision & Value Theory</u>, Wiley, 1964, NY, and Kaufman, <u>Theory of Fuzzy Subsets</u>, Academic Press, NY, 1975.

APPENDIX D
MODEL EVALUATION

D-1. INTRODUCTION. a. Early war gaming models were totally manual affairs. These games permitted qualitative analyses of the command and control aspects of a staff. Table tops served as displays. Stochastic calculations were done based on the roll of dice. Manual war games were then very strong on logic but weak on computational aspects. With the advent of computers, the random throw of the die could be replaced by computer algorithms. For a time manual war games were interspersed with computer runs. Some of these games evolved to take the form of programs featuring humans at interactive consoles, usually in the role of decision makers.

b. In its presently evolved form, the computer war game is usually weak on command and control logic since humans have been taken out and replaced with table "lookups." Conversely, the games are strong on firepower calculations, calculations of logistics, and, in fact, all of those items which had once been table "lookups" in the early manual war games.

c. In order to reintroduce analysis of command and control into combat simulations, we must again include the staff. We could in effect go all the way back to the original manual war games. This is being done at the TRADOC Combined Arms Test Activity in the various command post exercises and workshops. However useful these manual exercises may be, an iterative analytical tool is to be desired as well. Such a computer alternative, or complement to these manual tests, would be a simulation of the combat process coupled with the command and control processes. An ideal model would be totally automated, include reasonable decision making algorithms, and include the components of a command and control system (detailed previously). This would then allow comparison of competitive systems in a combat environment.

D-2. MODEL DISCUSSION. A cursory review of existing computerized models was made to ascertain the ability of existing models to simulate command and control or the feasibility of their being modified to incorporate a command and control simulation. No attempt was made to totally analyze the applicability of each. A list of these models*, with evaluative comments, follows:

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*For a brief description of these (except DIVOPS and FOURCE) and other models, refer to Catalog of War Gaming and Military Simulation Models, Studies, Analysis and Gaming Agency, 6th Ed, June 1975, H. J. Walther, NTIS AD/A-012 803.

<u>ADVICE II</u>. A computerized division echelon manual game (i.e., containing an external decision-maker) of 1967 vintage which can demonstrate the efficiency of information flow but not its combat effectiveness. Run times are long: 2 days per 10 hour battle.

<u>CAMMS</u>. Brigade resolution computer assisted game designed as a training vehicle for an external decision maker (and staff).

<u>CARMONETTE</u>. Computerized two battalion model with tactics pre-determined by a "decision maker" and provided as part of the input data. Many conditions alter the implementation of the decisions. Designed and/or used to study tactics and mixes of forces.

<u>COMMEL II.5</u>. An improved versions of COMMEL (1963 vintage). Heavy on simulation of communications systems; coupled with a divisin combat simulator but with simplistic and deterministic decision logic based on abstract dimensionless intelligence levels and modified firepower ratios.

<u>DIVSIFT</u>. A COBOL simulation of the manual staff functions in a division TOC; does not consider combat decisions, cannot be used for automated command and control systems, and is not coupled with a combat simulator. Inoperable.

<u>DIVOPS</u>. Division level fully automated combat simulation with user provided decision rules based on perfect information. No command, control or communications.

<u>DYNTACS</u>. Battalion level combat simulator of extreme complexity. Decisions are as complex as CARMONETTE, but information flow is minimal although some tactical communications is inlcuded. Useful in comparisons of ground vehicular weapon systems.

<u>FOURCE</u>. TRASANA version of DIVOPS with extensive rebuild of subroutines to account for the command and control process; totally automated. Model development is currently in process with test and validation due for completion CY77. Documentation is incomplete, but the model is intended to include sufficient resolution to analyze the Division Command and Control system. Current test and production is in support of CACDA's CEATOS effort which analyzes Division Command and Control system alternatives.

<u>TACOS II</u>. Similar to COMMEL in many aspects but reportedly providing better decision algorithms based on each unit's estimate of the enemy situation drawn from a normal distribution whose mean is the true enemy location, size, speed, and direction with a variance related to the quality of the intelligence. Combat outcomes depend on the true enemy situation and the applied firepower. If

it operates as claimed in the documentation, it would rank high among all models surveyed; TACOS II has not been located.

D-3. EVALUATION. None of the above models appear to consider the pre-combat planning phase. They are concerned with the combat process and the possible modification of the plan. Except for FOURCE, none in their present state were judged suitable for evaluation of command and control systems; however, FOURCE is in the process of development. DYNTACS and CARMONETTE may be suitable for modification to account for the Battalion Command and Control system.

APPENDIX E
HUMAN RESEARCH NEED

E-1. REQUIREMENT. Basic research is needed to provide a basis for a simulation of the decision making process at battalion level. Information and data are in the following areas:

a. Identification, isolation, and quantification of the human and environmental factors that impact on decisions made by the battalion commander (and staff) in his individual application of the traditional troop leading procedures and the sequence of command and staff actions in the development of orders for the command and control of the battalion under combat conditions.

b. Determine if the factors identified above can be grouped to represent a composite, or typical, battalion level decision maker.

c. Determine the correlation, if any, between this composite battalion commander decision making process and the traditional process using troop leading procedures and the sequence of command and staff actions.

d. Can objective probabilities be assigned to decision input factors to enable calculation of the probability of arriving at a particular decision? If so, what are they?

E-2. USE. Data resulting from this effort will be used in the simulation of both maneuver battalion and artillery battalion combat. A purpose of the simulation would be to compare current and proposed systems which impact on the decision process (e.g., target acquisition, electronic warfare, communications, information processing and analysis) as to their effect on the combat resulting from the decision process.

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